The Physiological Effects of Low Atmospheric Pressures, as Observed on Pike's Peak, Colorado. (Preliminary Communication.)

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The following is a short preliminary account of a series of observations made in the summer of 1911 on the summit of Pike's Peak, Colorado.

Pike's Peak is 14,109 feet above sea-level, the barometric pressure on the summit being about 18 inches (457 mm.). There is an excellent stone house close to the summit, in which we were accommodated during our stay of five weeks. The main object of the expedition was to discover to what extent, and by what means, adaptation takes place to low barometric pressure and consequent deficiency in the partial pressure of oxygen in the air.

Our chief conclusions are as follows:—

(1) After two or three days on the summit of Pike's Peak very distinct signs of acclimatisation began to appear.

(2) Before acclimatisation occurred blueness of the lips and face, nausea, intestinal disturbance, headache, fainting in some persons, and periodic breathing were observed, besides great hyperpnœa on exertion or holding the breath for a few seconds.

(3) All these symptoms are referable, directly or indirectly, to want of oxygen, produced by the diminished partial pressure of oxygen in the air. We did not observe, either in ourselves or in the large number of persons who ascended the Peak, any symptoms (apart from the effects of the bright light) not referable to the same cause.

(4) After acclimatisation had occurred these symptoms disappeared, with the exception that hyperpnœa on exertion or on holding the breath for a few seconds was still much greater than usual. Periodic breathing was still observed occasionally, and blueness of the lips and face was present after continuous and fairly powerful exertion, such as walking up hill.

(5) The respiratory exchange during rest remained about normal in the one subject on whom exact experiments were made, and the respiratory exchange during work did not appear to be markedly increased.

(6) After acclimatisation the alveolar carbon dioxide pressure was diminished from about 40 mm. to about 27 mm. during rest or moderate exertion, which corresponded to an increase of about 50 per cent. in the ventilation of the lung alveoli. During severe exertion the alveolar carbon dioxide pressure was about half what it normally is during similar exertion, which corresponded to an increase of about 100 per cent. in the hyperpnœa; and owing to a temporary alteration in the respiratory quotient the breathing was still further increased.

(7) The change in the level of alveolar carbon dioxide pressure occurred gradually after going up, and disappeared gradually on coming down, the change taking a number of days to reach completion.

(8) The percentage of hæmoglobin in the blood increased for several weeks on the summit of Pike's Peak, and varied in different acclimatised persons from 115 to 154 per cent. on the scale of the Gowers-Haldane hæmoglobinometer, corresponding to an oxygen capacity of from 21 to 28·5 c.c. of oxygen per 100 c.c. of blood. The number of red corpuscles per cubic millimetre of blood increased parallel with the hæmoglobin, and the percentage volume of red corpuscles, as determined by the hæmatocrit, also increased in proportion to the percentage of hæmoglobin.

(9) A large increase in the total amount of hæmoglobin (determined by the carbon monoxide method) in the body occurred during the first three weeks, and along with this increase there was found, except in the first week, a slight increase in blood volume, as well as the increase, already referred to, in the percentage of hæmoglobin.

(10) On coming down from Pike's Peak the hæmoglobin percentage diminished much more rapidly than the total hæmoglobin, so that the blood-volume was still further increased at first. It required about four weeks for the excess of hæmoglobin and blood-volume to disappear, though the hæmoglobin percentage fell to normal much earlier.

(11) So far as we could ascertain, there was very little change in the rate of circulation on Pike's Peak after acclimatisation. Pulse and blood-pressure were but little affected. In most cases, however, there was a slight increase in the pulse rate.

(12) After acclimatisation the oxygen pressure in the arterial blood (measured by the carbon monoxide method) rose during rest to about 35 mm. of mercury above the alveolar oxygen pressure (66 per cent. higher), and remained at a level of only about 12 mm. below the normal oxygen pressure at sea-level. Immediately after ascending the Peak and before acclimatisation had occurred, the arterial oxygen pressure was found to be about 45 mm. below normal, and only slightly above the alveolar oxygen pressure. This change

appears to be due to a progressive increase in the activity of the alveolar epithelium in secreting oxygen inwards. On raising the alveolar oxygen pressure to normal, the difference between alveolar and arterial oxygen pressure diminished rapidly.

(13) Acclimatisation to high altitudes is due mainly to the increased secretory activity of the alveolar epithelium, but partly also to the increased lung ventilation, and to a lesser extent to the increased hæmoglobin percentage in the blood. The acclimatisation takes some days to develop. During rapid ascents in balloons or aeroplanes it would not have time to develop, and this explains the contrast between the experience of balloonists, etc., and that of mountaineers who ascend gradually.

The Development of a Leucocytozoon of Guinea-Pigs.

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[Plate 1.]

The presence of "bodies" within the large mononuclear leucocytes of guinea-pigs was first noticed by Kurloff (1898). He described them as inclusions; for in a drop of guinea-pig's blood he noted that many of the large lymphocytes contained, within their cytoplasm, clear, spherical vacuoles which were distinct from the nucleus, and which had not been described before; and he suggested the possibility of these bodies being accessory nuclei. Since their discovery by Kurloff they have been subjected to much research; and papers describing various observations concerning them have been published by Burnett (1904), Staubli (1905), Goldhorn (1905), Ledingham (1906), Howard (1907), Pappenheim (1908), Patella (1908), Hunter (1909), and Schilling (1911).

Kurloff noticed that when the blood containing these bodies was fixed and stained, they contained a nucleus-like structure staining with nuclear dyes, but he believed them to be vacuoles formed by a secretion product of the cells which held them. Ehrlich (1906) also thought that Kurloff's bodies represented some "Secretstoff." Dr. Ledingham, to whom I am indebted